Using LiDAR to identify sinkholes and other depressions in the Shenandoah Valley of Virginia

Matt Heller, John Wall, and Lorrie Coiner

Virginia Department of Mines, Minerals, and Energy
North Carolina State university

DMME
Virginia Department of
Mines Minerals and Energy

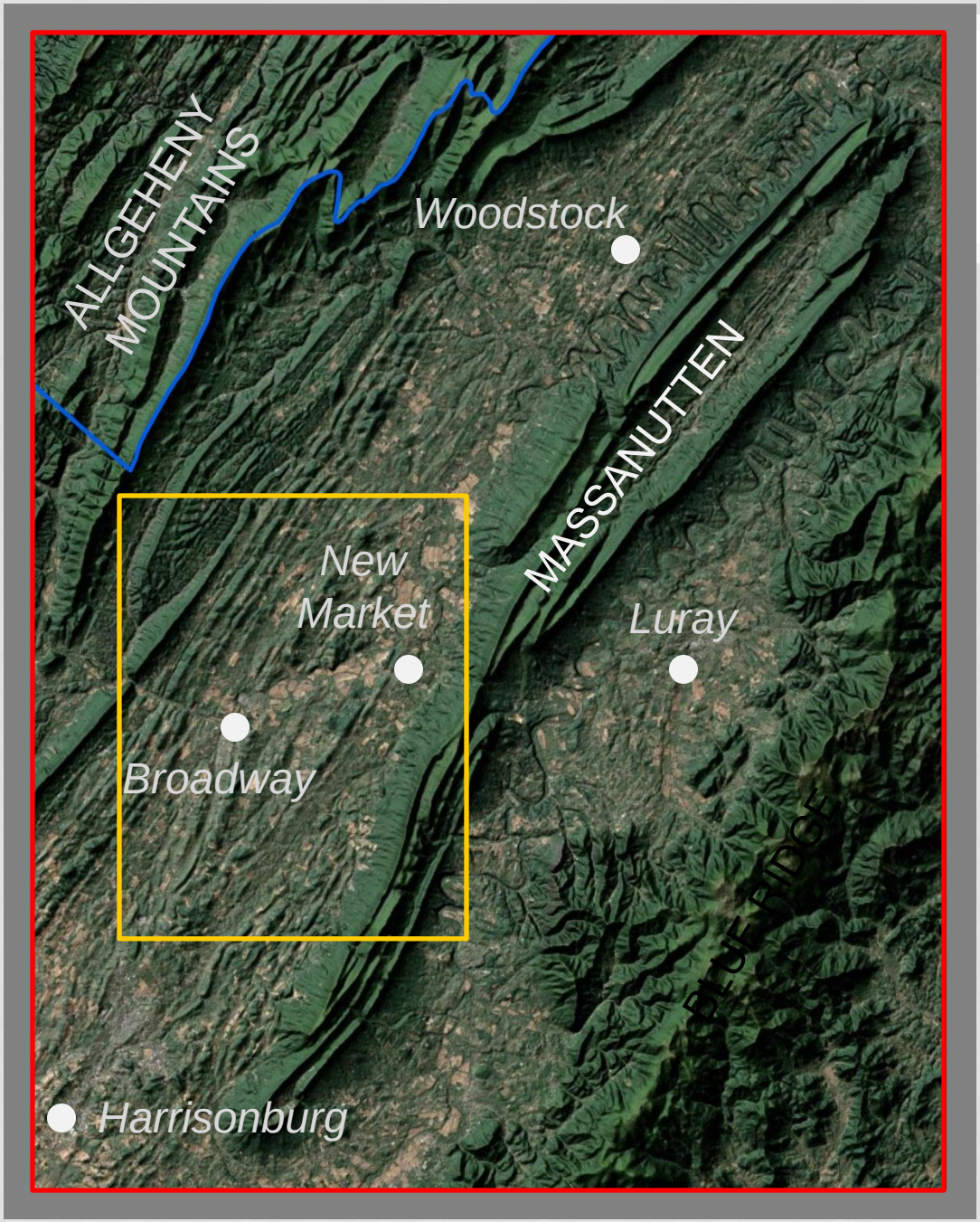
NC STATE
UNIVERSITY

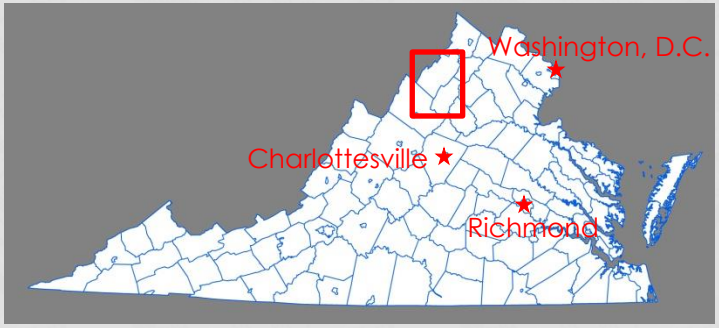
SINKHOLES AND WHY ARE THEY IMPORTANT

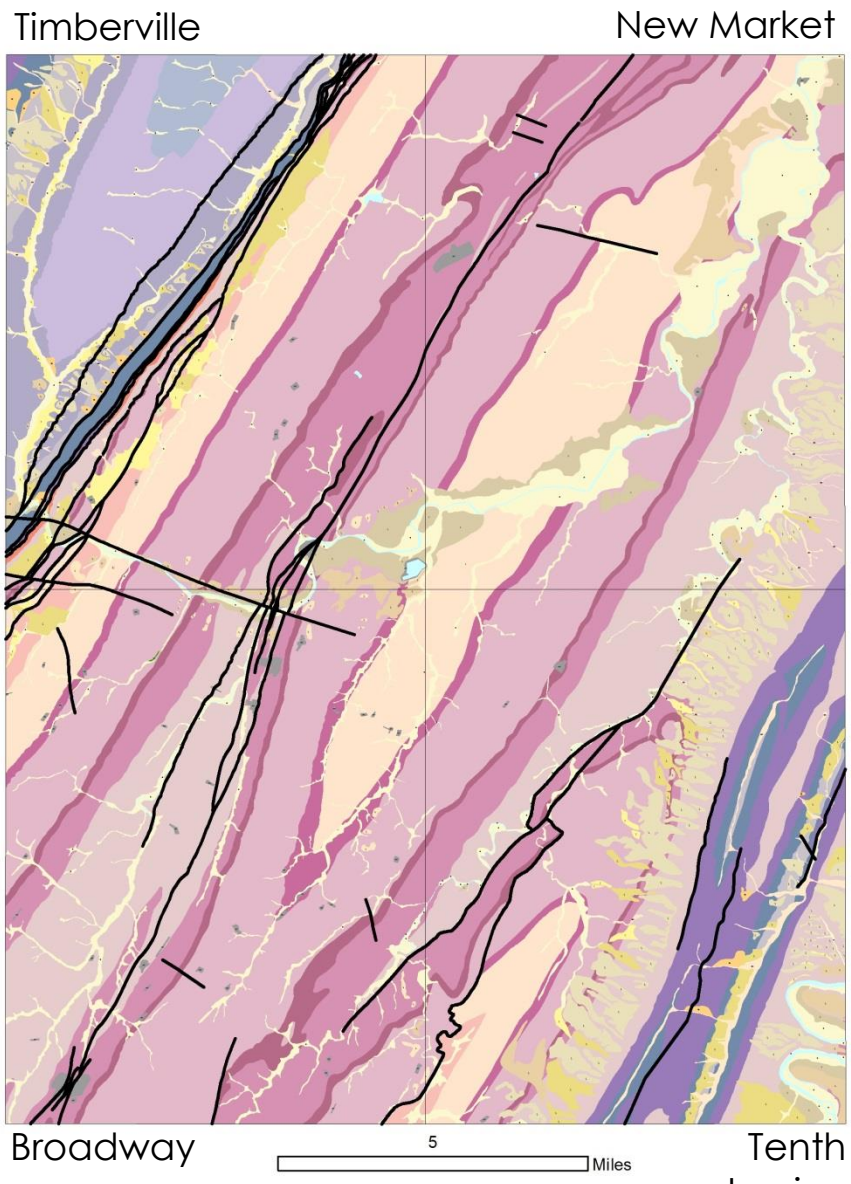
- A "sinkhole" is a depressed area that has no external drainage.
- Sinkholes are one part of a karst landscape that includes losing streams, springs, and caves.
- Sinkholes capture surface runoff as well as infiltrating ground water.
- Water that enters an aquifer through a sinkhole probably receive less filtering.

AREA OF STUDY

CENTRAL SHENANDOAH VALLEY





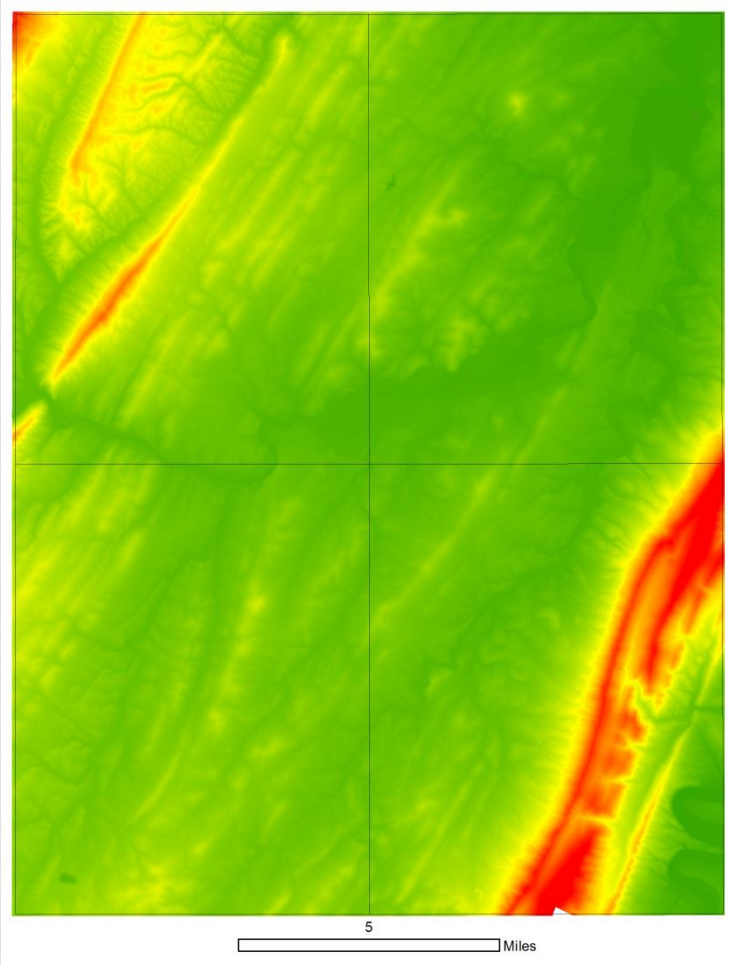


	Formation	Thickness(ft)
DEVONIAN	Hampshire Formation	2,000
	Foreknobs Formation	2,200
	Brallier Formation	1,000 to 1,800
	Millboro Shale	400
	Needmore Formation	
	Ridgeley Sandstone	55
	Helderberg Group	400
SILURIAN	Tonoloway Limestone	200
	Wills Creek Formation	150
	Bloomsburg Formation	87
	Keefer Sandstone (Massanutten Sandstone)	53
	Rose Hill Formation (Massanutten Sandstone)	210
	Tuscarora Formation (Massanutten Sandstone)	53 to 130
ORDOVICIAN	Juniata Formation	50 to 300
	Oswego Sandstone	50 to 600
	Martinsburg Formation	1500 to 3,000
	Edinburg Formation	425 to 1500
	Linconshire Limestone	340 to 460
	New Market Limestone	
	Beekmantown Formation	about 3,000
	Stonehenge Limestone	450 to 550
CAMBRIAN	Conococheague Formation	1,500 to 2,500
	Elbrook Formation	2,000 to 2,500

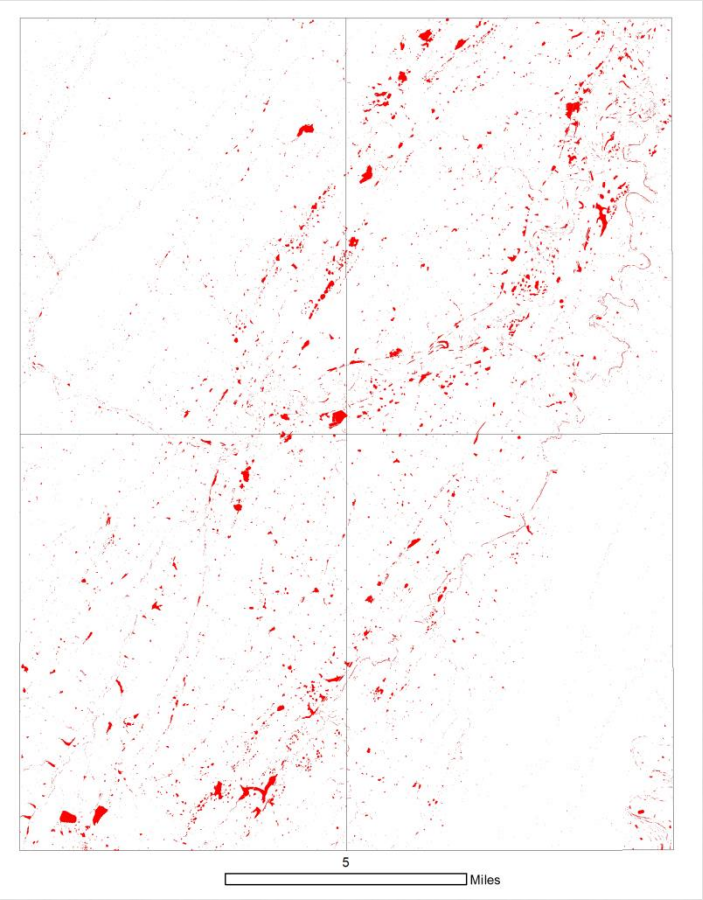
Carbonate

Carbonate

LIDAR DATA AND DEPRESSIONS

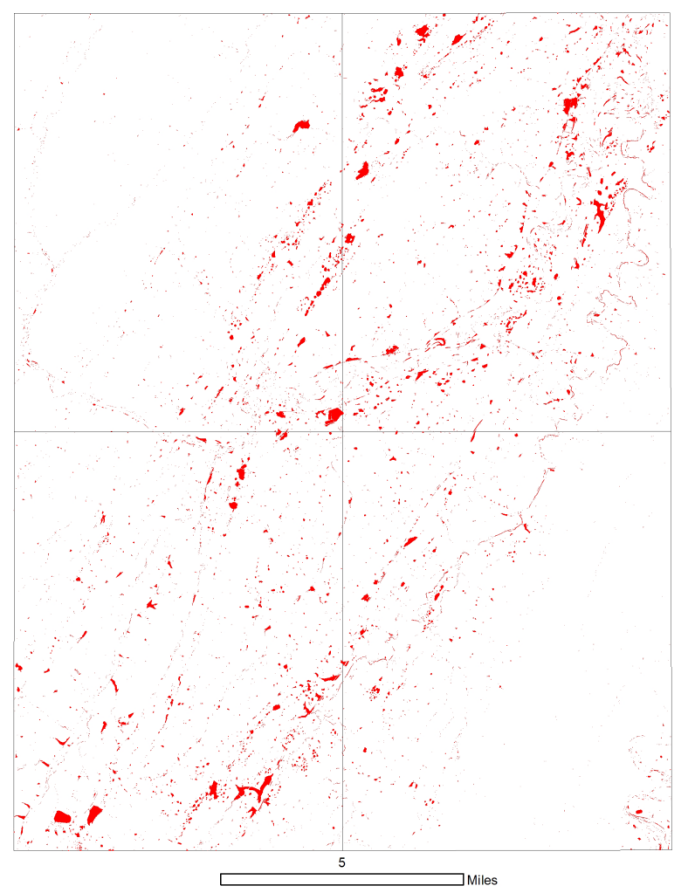


Digital Elevation Model

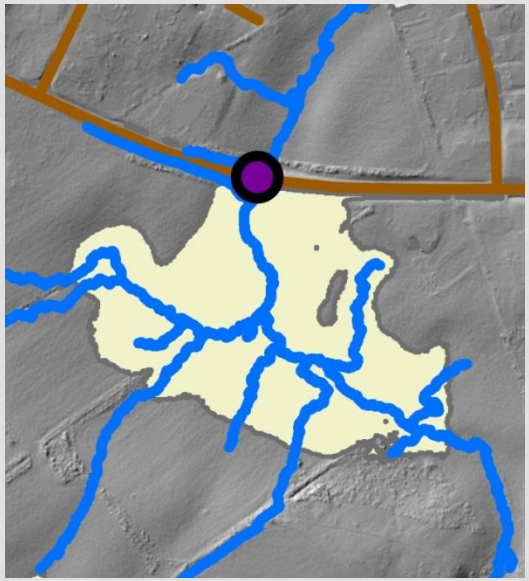


347,839 depressions detected

A MORE MANAGEABLE DATASET



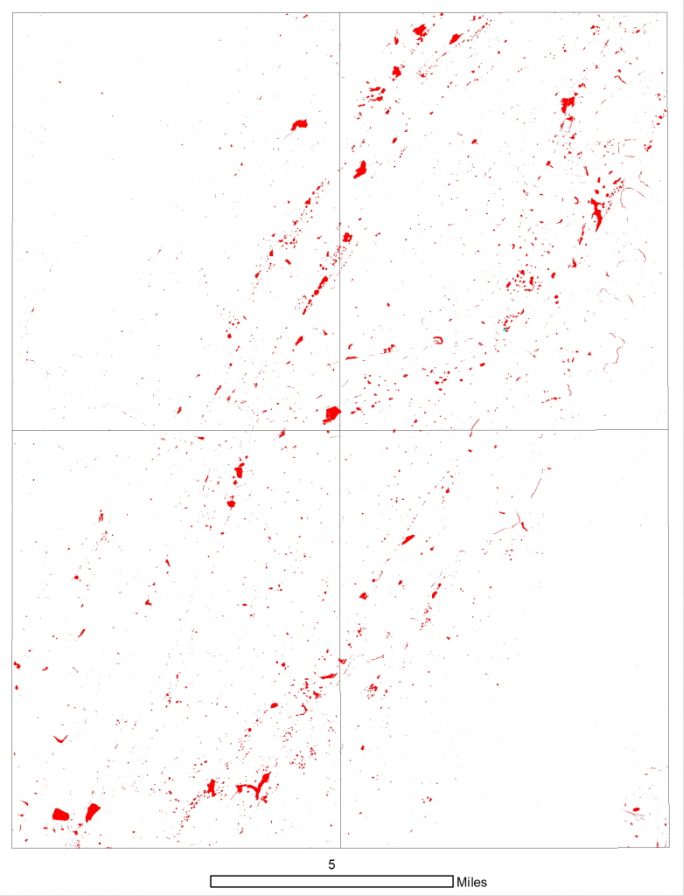
25,927 depressions > 100 ft^2



Hydrocutter Tool (Wall, 2015) removed 1,171false depressions related to culverts and bridges

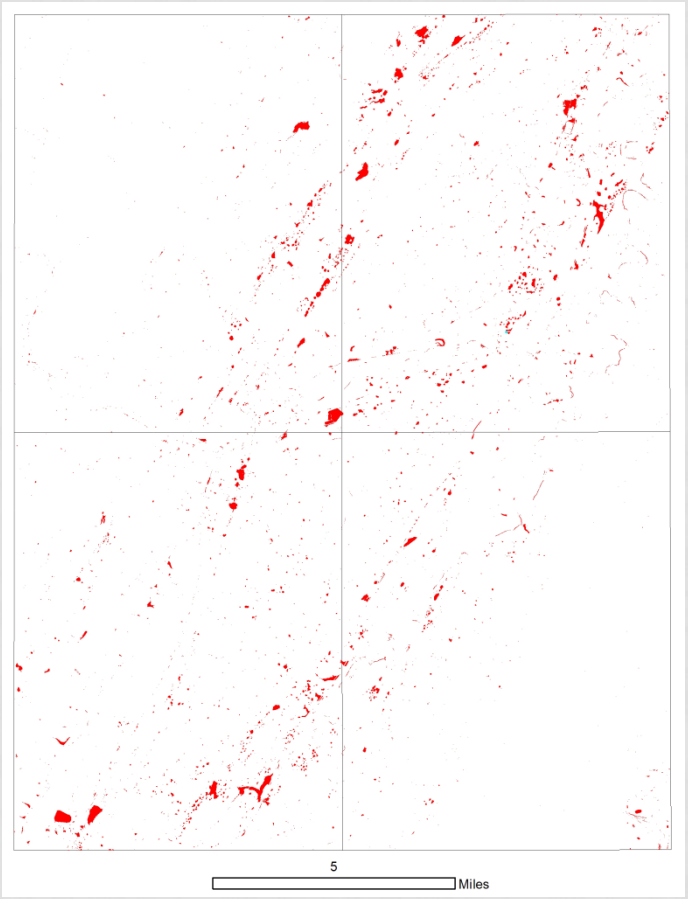
Even after this tool was used, random sampling suggested more than 80% of depressions were "false" sinkholes

A REASONABLE DATASET TO QA/QC

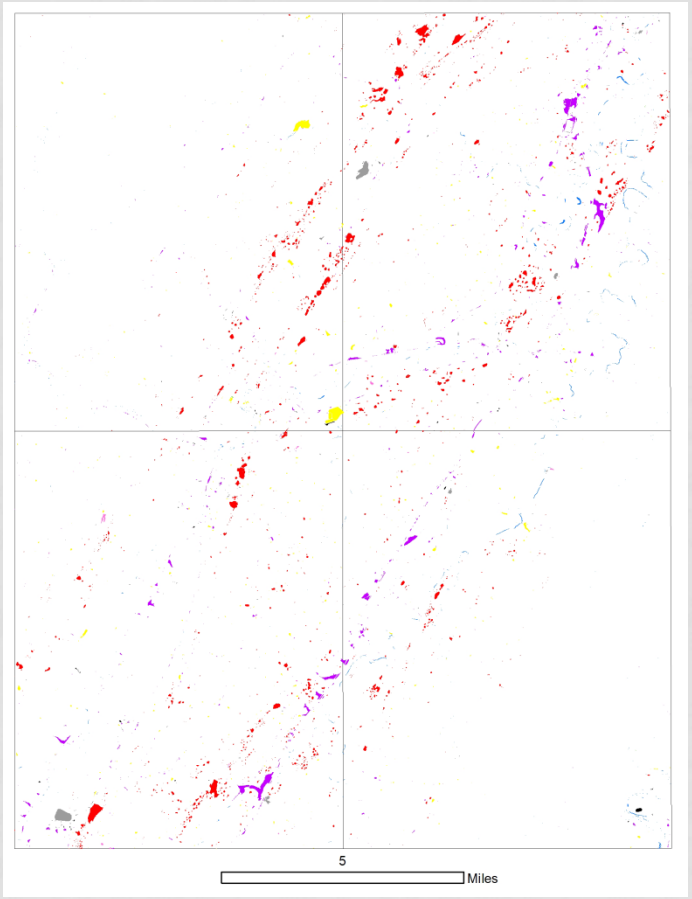


8,233 depressions >100 ft^2
and >0.9 ft deep

THREE DAYS LATER…

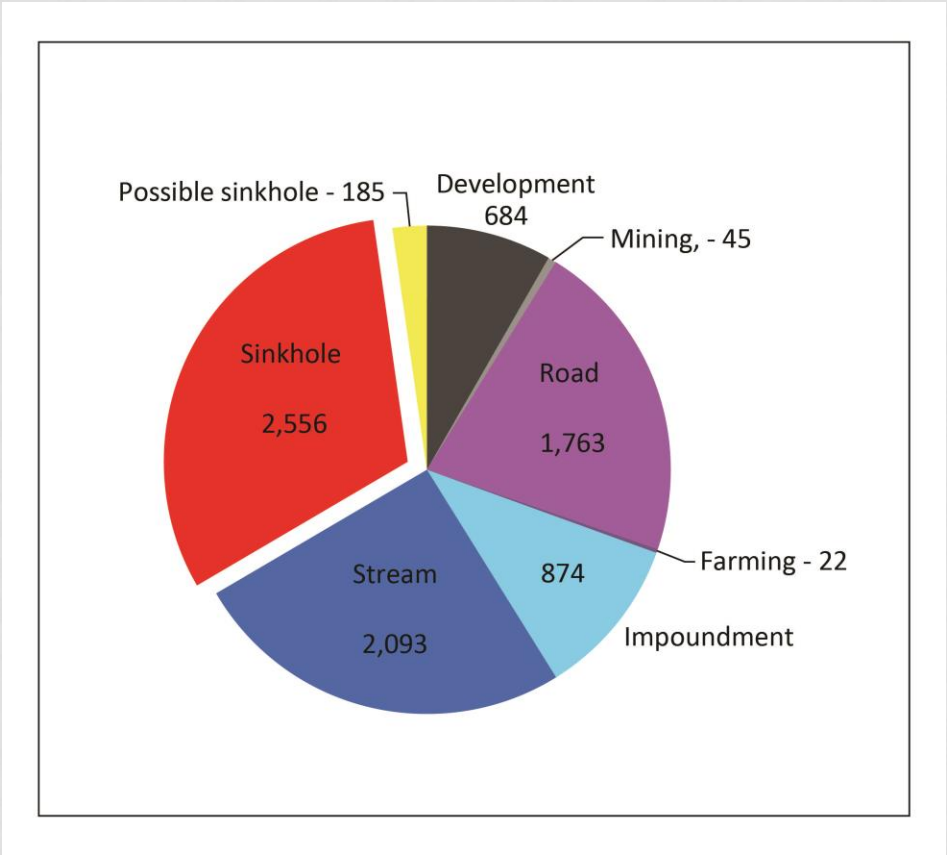


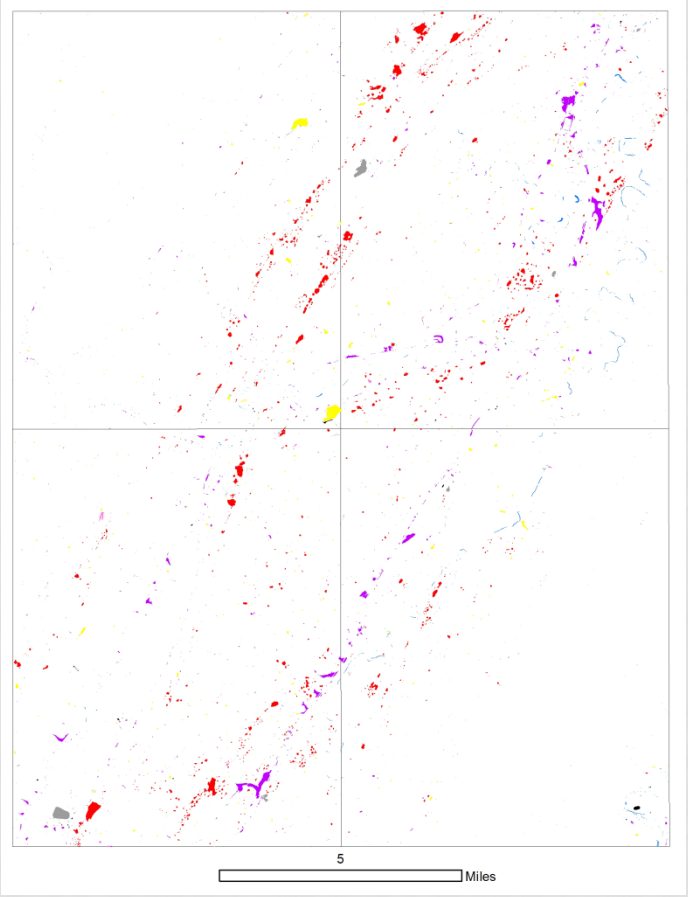
8,233 depressions >100 ft^2 and >0.9 ft deep



Depressions were classified into eight categories

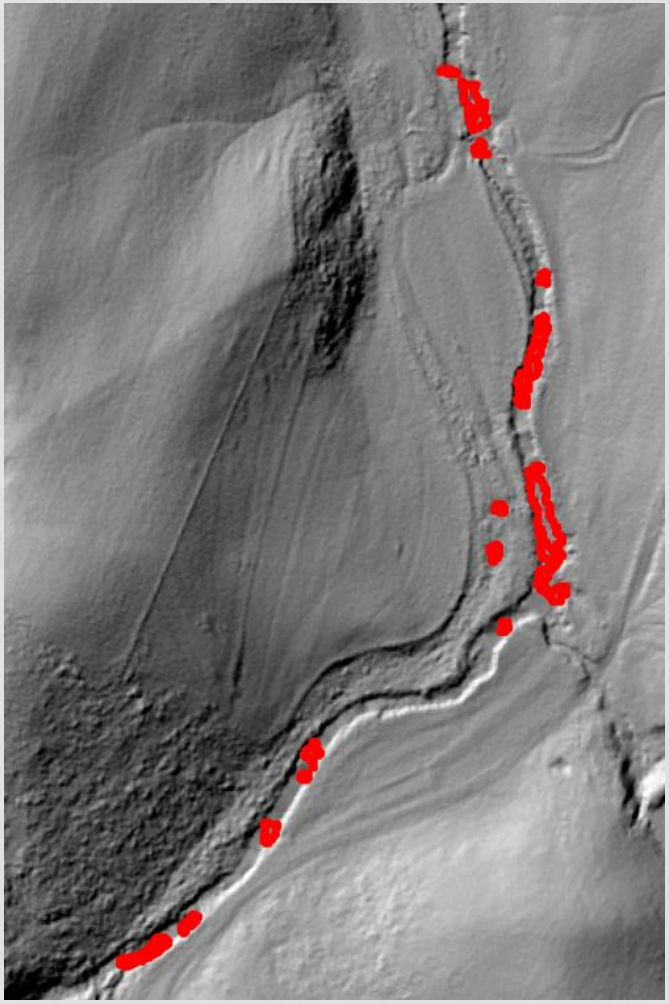
SINKHOLE CLASSIFICATION

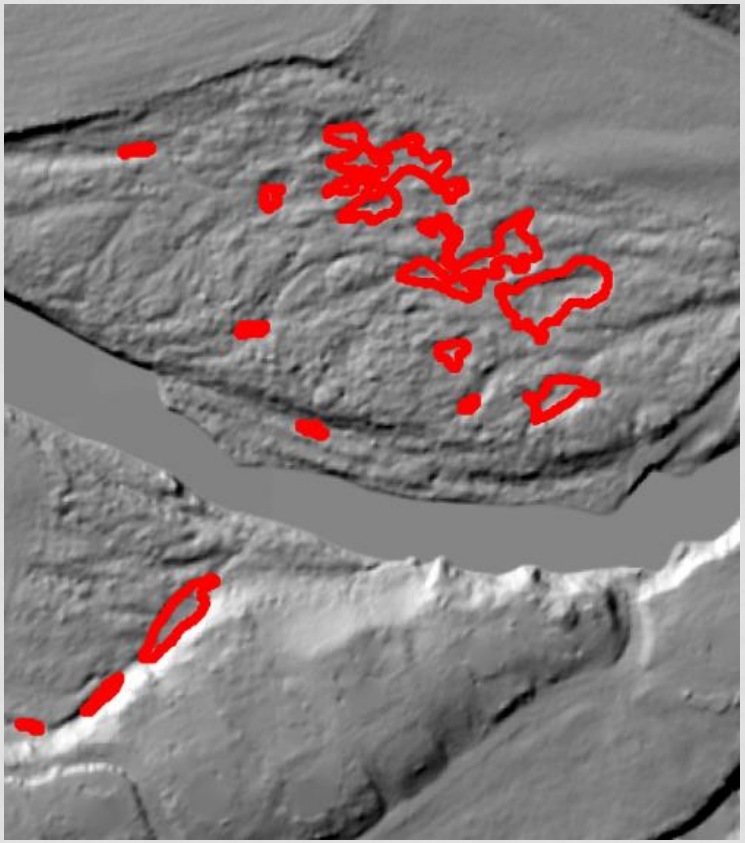




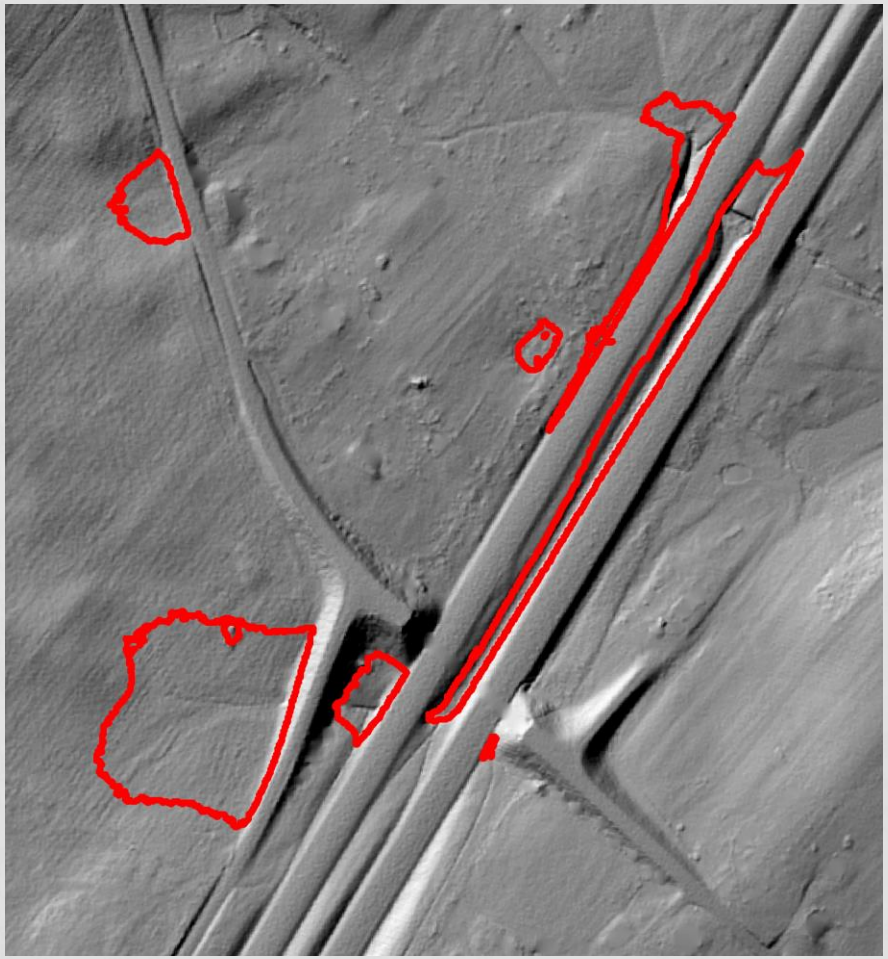
Depressions were classified into eight categories

EXAMPLE – STREAM-RELATED DEPRESSIONS

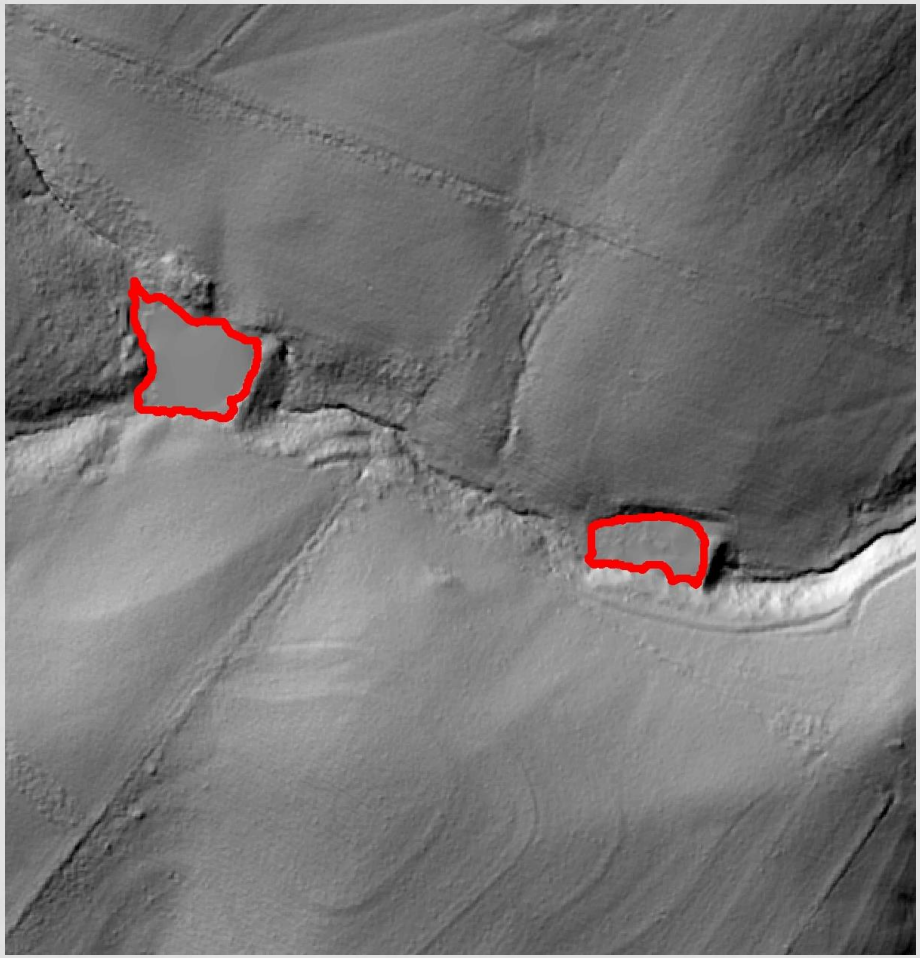




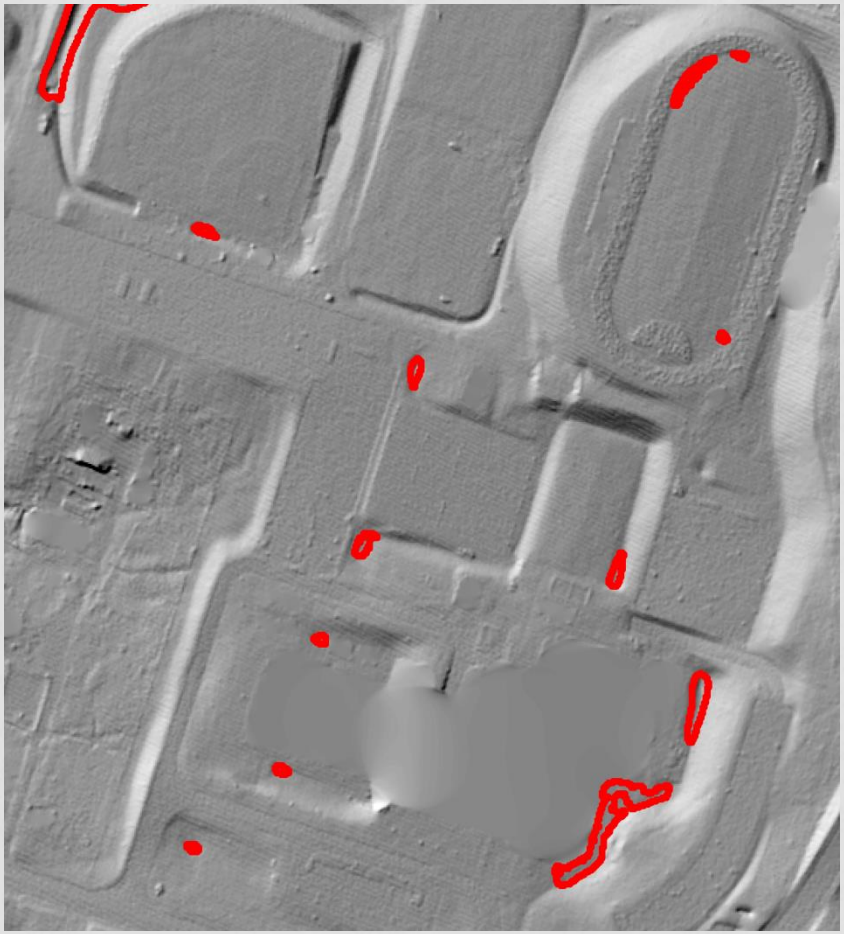
EXAMPLE – ROAD-RELATED DEPRESSIONS



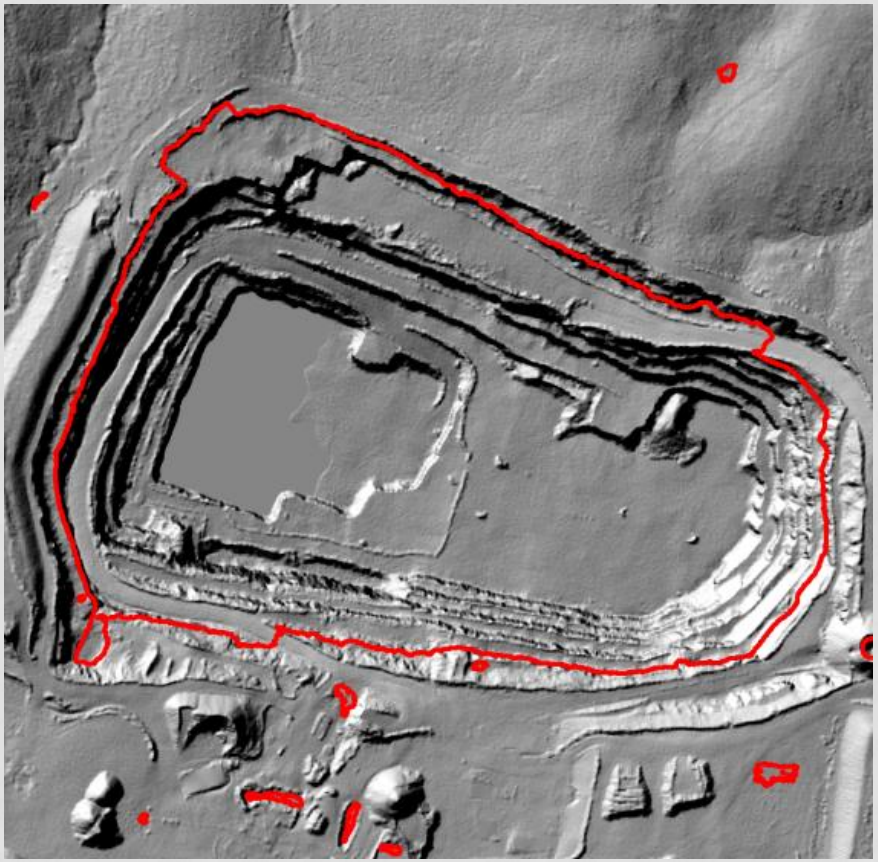
EXAMPLE – IMPOUNDMENTS

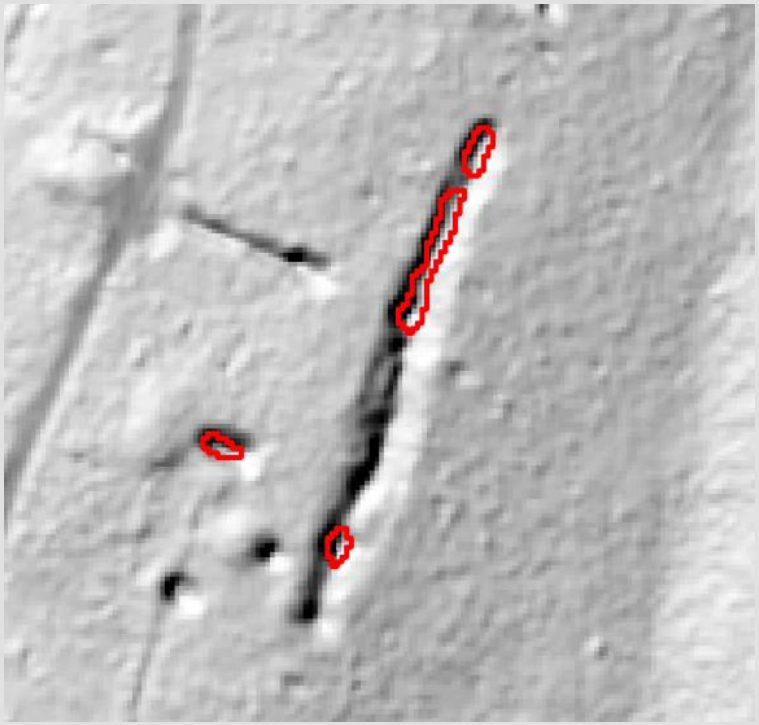


EXAMPLE – DEVELOPMENT-RELATED DEPRESSIONS

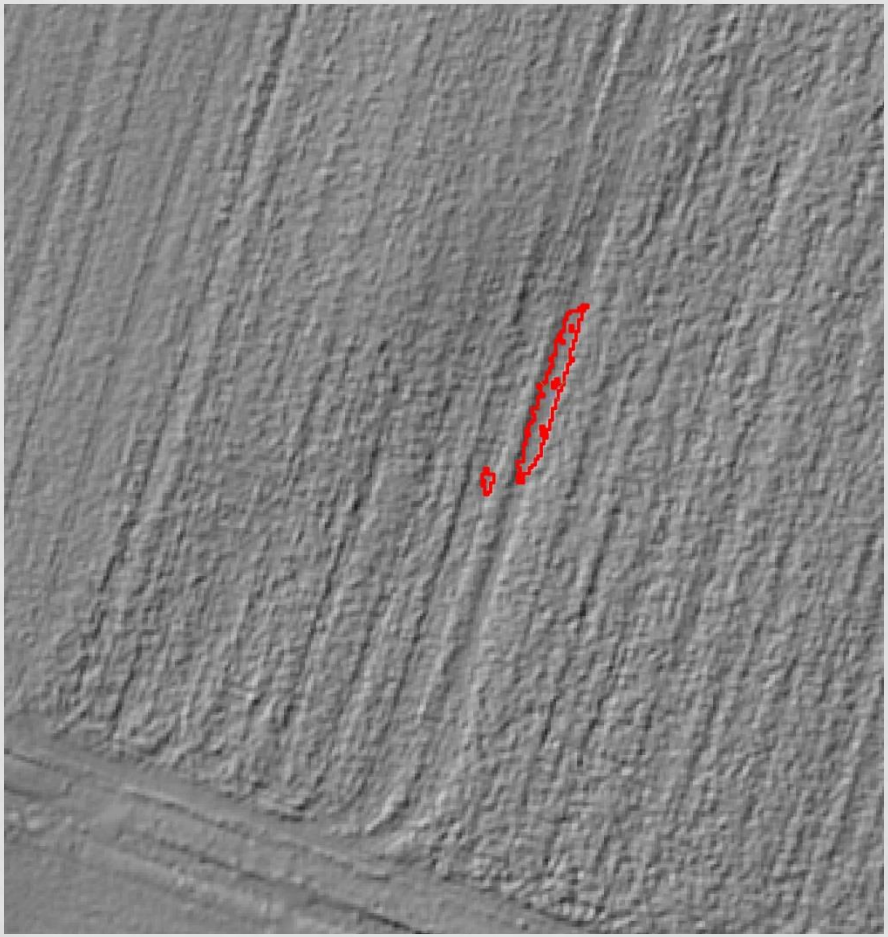


EXAMPLE – MINING-RELATED DEPRESSIONS

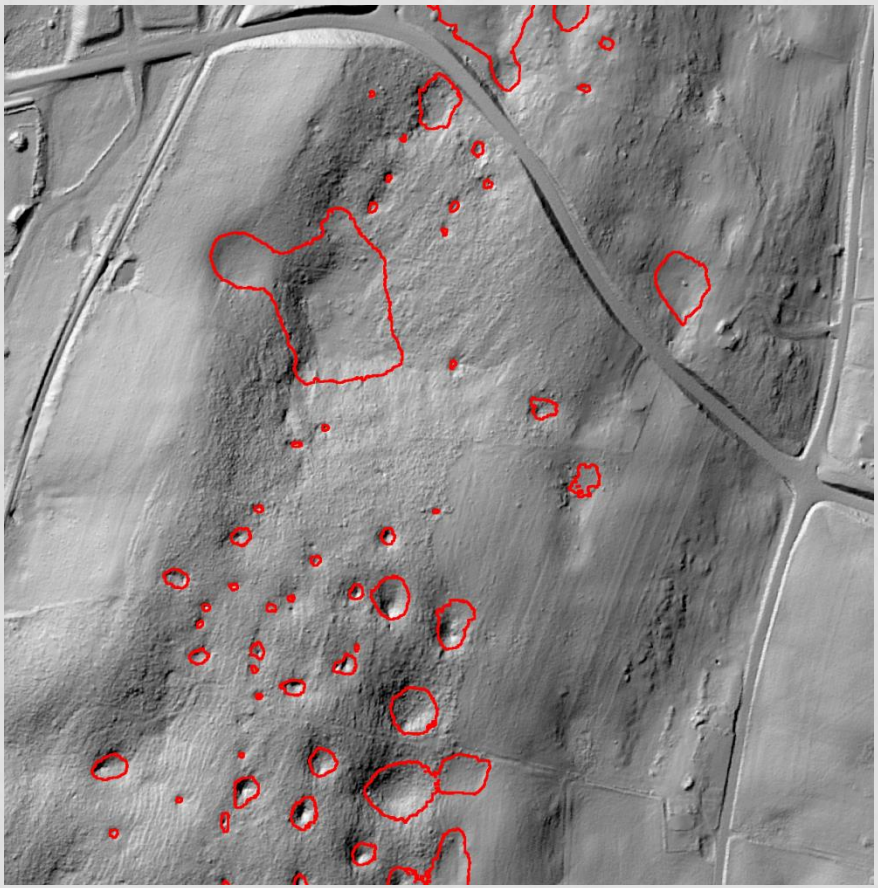




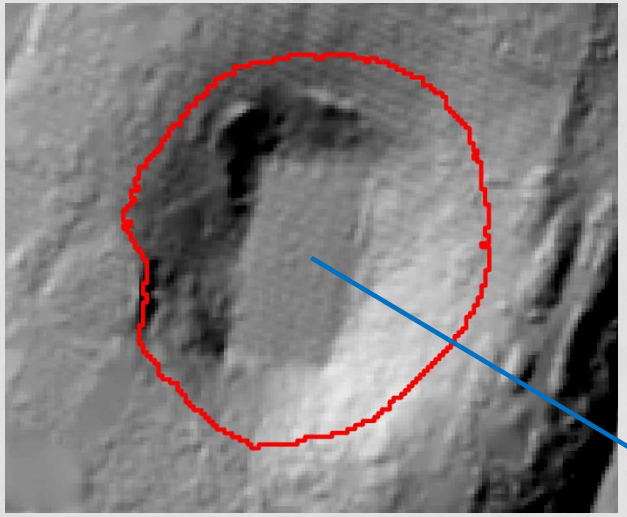
EXAMPLE – MINING-RELATED DEPRESSIONS

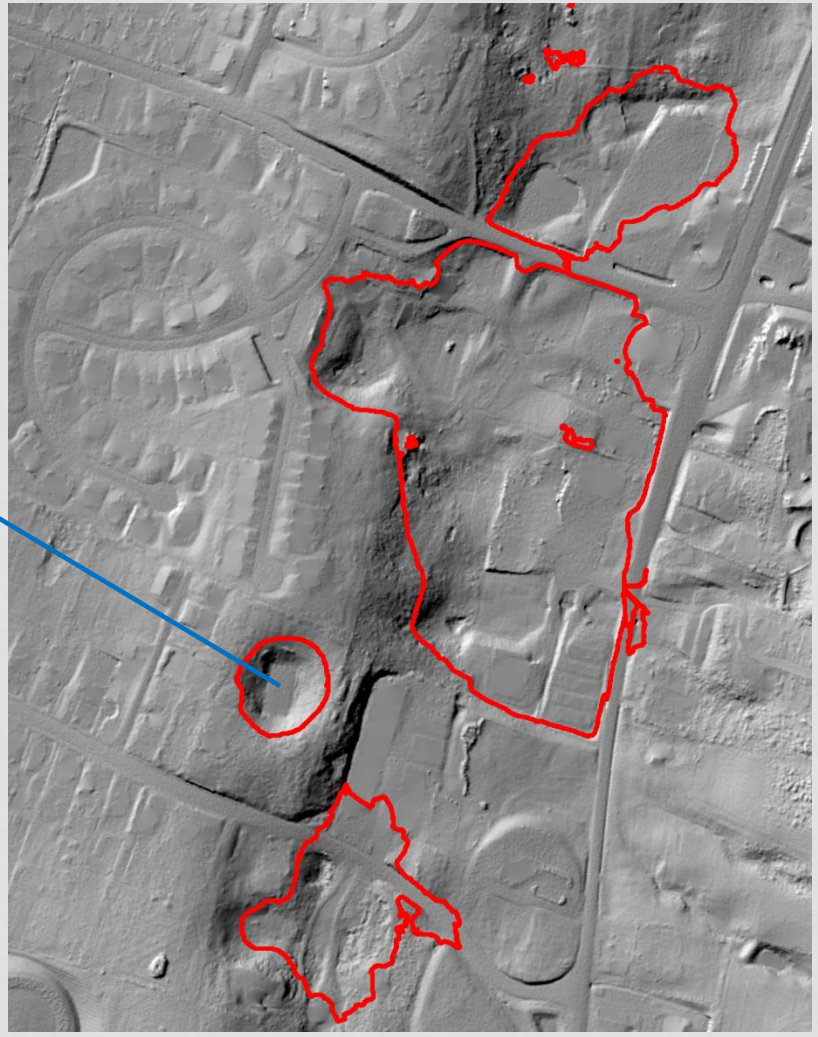


SOME ACTUAL SINKHOLES



MODIFIED SINKHOLES



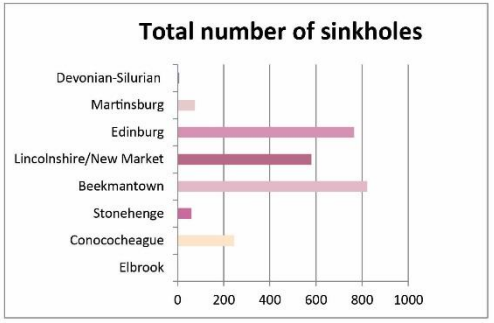


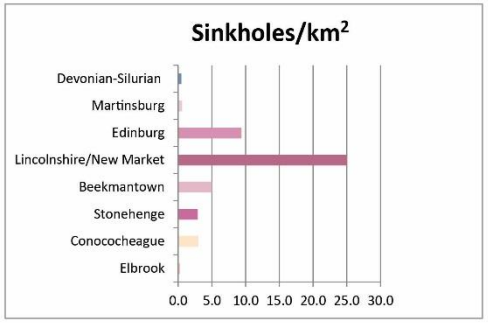
PRELIMINARY RESULTS

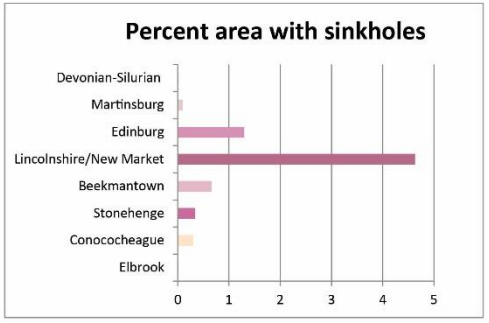
Carbonate

Carbonate

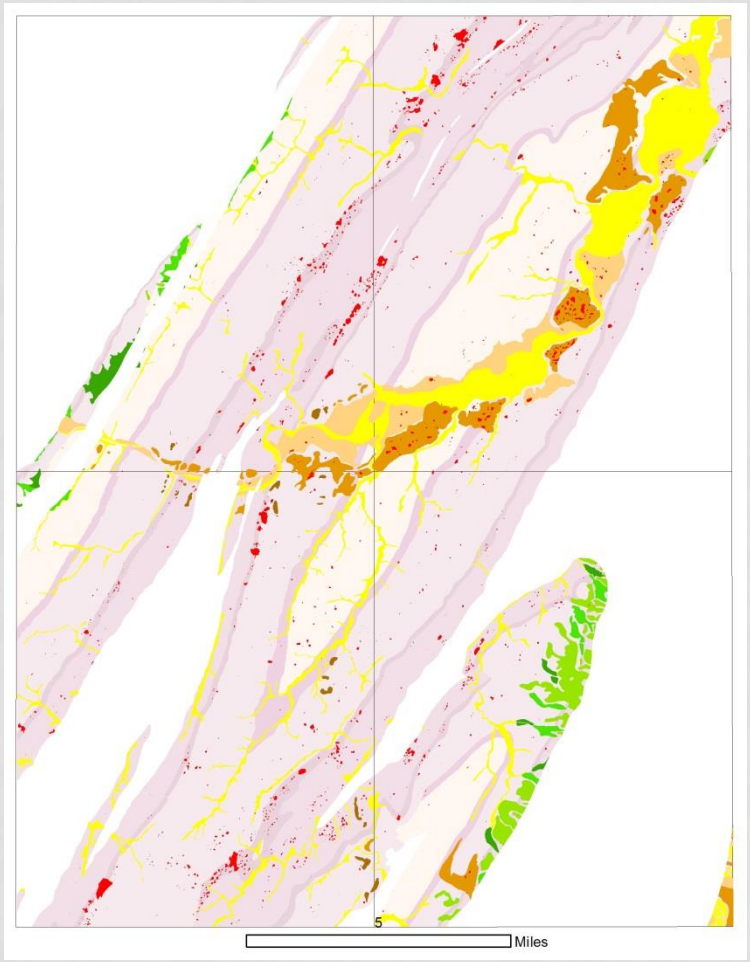
	Formation		Thickness(ft)
DEVONIAN	Hampshire Formation		2,000
	Foreknobs Formation		2,200
	Brallier Formation		1,000 to 1,800
	Millboro Shale		400
	Needmore Formation		
	Ridgeley Sandstone		55
	Helderberg Group		400
SILURIAN	Tonoloway Limestone		200
	Wills Creek Formation		150
	Bloomsburg Formation		87
	Keefer Sandstone	Massanutten Sandstone	53
	Rose Hill Formation		210
	Tuscarora Formation		53 to 130
ORDOVICIAN	Juniata Formation		50 to 300
	Oswego Sandstone		50 to 600
	Martinsburg Formation		1500 to 3,000
	Edinburg Formation		425 to 1500
	Linconshire Limestone		340 to 460
	New Market Limestone		
	Beekmantown Formation		about 3,000
	Stonehenge Limestone		450 to 550
CAMBRIAN	Conococheague Formation		1,500 to 2,500
	Elbrook Formation		2,000 to 2,500



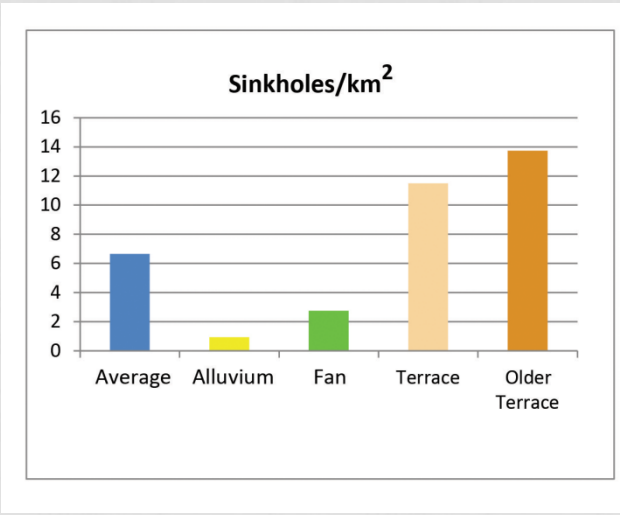




PRELIMINARY RESULTS



Surficial Deposits underlain by Conococheague to Edinburg Formations



CONCLUDING THOUGHTS

Within the area of study:

- All carbonate formations have some potential for sinkholes, but Middle Ordovician formations have significantly higher densities of sinkholes.
- The New Market/Lincolnshire map unit has larger sinkholes on average than other formations.
- Areas overlain by older terrace deposits the North Fork of the Shenandoah River have twice the average frequency of sinkholes in carbonate formations.
- >100 square ft and >1 foot depth are probably good thresholds for 1:24,000-scale work in this area.
- Lidar is a useful tool for locating sinkholes, but significant QA/QC is required.